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Framing the Climate Debate: Knowledge Affirmation vs. Risk Mitigation

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Abstract

Opinions regarding the anthropogenic climate change hypothesis (ACC), along with the possibility of subsequent catastrophic environmental impacts, often break down along ideological lines that have lead to a dichotomy between “believers” on the one hand, and “non-believers” on the other. Although some scientific uncertainty remains, the current body of scientific evidence supporting the hypothesis is significant and enough to warrant consideration of a strong policy response. However, for any progress to be made on the policy front, the existing ideological dichotomy between believers/non-believers must be overcome. This will require policy advocates, including scientists, to do a much better job framing the scientific argument for policy intervention more in terms of inherent scientific uncertainty and risk mitigation instead of suggesting that scientific outcomes and subsequent catastrophic events are indisputable. Much can be learned regarding a proper framing of climate science through philosophical reflection of the metaphysical and epistemological nature of science, and by considering similar historical examples of scientific knowledge assessment. Although reframing the debate in terms of the inherent scientific uncertainty is not sufficient to overcome all obstacles, having policy makers and the general public at large properly recognizing the nature of the scientific argument, instead of adhering to a believer/non-believer false dichotomy, is a necessary first step.

I. Introduction: Climate Change Ideology and the Believer/Non-believer Dichotomy

In June 2007, the American Association of Petroleum Geologists (AAPG) issued a statement moving from a dissenting to neutral position on anthropogenic climate change and even went so far as to say that “reducing emissions from fossil fuel use [is] a worthy goal” (AAPG, 2007). This change in position was significant as the AAPG was the last professional scientific body to reverse a previous position of fully dissenting to the anthropogenic climate change hypothesis (ACC). To date, all other scientific bodies either concur with the hypothesis or, like the AAPG, remain non-committal. Those concurring include the national academies of science from 32 developed and developing countries including India and China, professional scientific societies such as the American Physical Society, European Physical Society, and Royal Society, and human health institutions such as the American Medical Association, World Federation of Public Health Associations, and World Health Organization. Although some individual scientists within the community continue to dissent, they represent roughly a 2% minority (Anderegg et. al., 2010). While near consensus among experts does not constitute a scientific argument, and majority bodies of scientific experts have certainly been mistaken before, the scientific arguments themselves—consideration of which is beyond the scope of this paper—and other evidence supporting the anthropogenic climate change hypothesis is overwhelming and is sufficiently compelling to warrant *consideration* of a strong policy response.

Despite the concurrence among the aforementioned organizations and the lack of dissent from any professional scientific body, lingering debate concerning the strength of the scientific evidence continues within the general public where global warming has come to be regarded by many as an ideology. In a recent interview by Fox News shortly after the Copenhagen accord, Czech President Vaclav Klaus remarked, “I’m convinced that after years of studying the phenomena, global warming is not a real issue of temperature...that is the issue is of a new ideology or religion. A religion of climate change or a religion of global warming” (Koprowski, 2009). Indeed, Klaus’ reference to religion is an appropriate one. Lay persons and scientific experts, skeptics and believers alike often refer their stance on the issue much in the same way that one might believe in some moral code of conduct or deity. MIT atmospheric scientist Dr. Richard Lindzen in observing this phenomenon concluded that climate change had indeed “become a quasi-religious issue” (Lindzen, 2010). Perhaps the most extreme example of ideological faith in global warming comes from a UK court ruling where belief in climate change was granted the same legal protection as religious belief. In the landmark ruling executive Tim Nicholson was granted permission to sue his former employer for discrimination based on his “belief in man-made climate change” as “a philosophical belief that reflects moral and ethical values.” In his opinion, Justice Michael Burton concluded, “a belief in man-made climate change...is capable, if genuinely held, of being a philosophical belief for the purposes of the 2003 Religion and Belief Regulations” (Adams, 2009).

Addressing scientific theories and evidence in terms of an ideological distinction between believers and non-believers or skeptics is problematic in that it creates a false dichotomy that misrepresents the nature of knowledge obtained using the scientific method, and makes it difficult for any objective assessment of the knowledge for policy purposes. Skeptics often view climate science as something of which they are entitled to

their own opinions, while many believers—including policy advocates and climate scientists acting as policy advocates—view the scientific evidence in support of the anthropogenic climate change hypothesis and predictions of catastrophic outcomes as indisputable. Although the scientific community isn't entirely to blame for the emergence of this dichotomy, many within the community are accountable for perpetuating the dichotomy by portraying the science in terms of indisputable truth claims instead of making the painstaking effort to educate the general public on the inherent scientific uncertainty and complexity of climate science.

Perhaps in an attempt to sway public perception, present the strongest possible case for policy intervention, and to counteract opposition by special interests in the energy sector such as large oil and coal companies that would stand to lose market share should any carbon mitigating policy be enacted, many scientists operating as activists have embraced a believer/skeptic dichotomy and have promoted the science largely as indisputable without adequately acknowledging inherent uncertainty in both the empirical evidence and theoretical models. An appeal to absolute certainty by scientist advocates in favor of a strong policy response is enticing for multiple reasons. First, in a media era dominated by brief sound bites with limited critical discussion, explaining the uncertainty surrounding climate science to the general public is arduous. Second, as much discussion of policy within the political establishment is framed in absolutist-type dichotomies that fall along party lines, scientist activists may have found it easier to adapt to the rhetoric of the political establishment rather than take on both the false-dichotomic structure of political discourse as well as presenting the scientific case for policy action. Third, scientist activists may have envisioned stakeholders who are opposed to a strong climate policy response portraying the uncertainty in the science as evidence that the anthropogenic climate change hypothesis is weak and that no policy action should be taken. By presenting the science as indisputable, policy advocates could easily avoid the perceived weakness in uncertainty.

Whatever the case may be, the dichotomy that has emerged has resulted in both sides entrenching themselves to the extent that knowledge assessment is no longer relegated to the confines of objective scientific inquiry and has been engulfed by political intervention and activism on the part of scientists beyond simply doing science as well as policymakers simply enacting policy. Examples of this kind of intervention in the assessment of climate science are abundant. On the political front we see in response to the University of East Anglia “climategate” controversy the Utah State Legislature issuing a joint resolution of their own assessment of the science calling global warming a “conspiracy” based on “flawed” evidence and that the risks attributed to global warming are unfounded (Gibson, 2010). Sensing a similar opportunity to respond to “climategate,” the United States Senate Committee on Environment and Public Works minority staff reported that the controversy “seriously compromise[ed] the IPCC-based consensus and its central conclusion that anthropogenic emissions are inexorably leading to environmental catastrophes” (Dempsey, 2010). In contrast to the U.S. Senate we see British Parliament defending the scientists involved in the controversy claiming that “actions were in line with the common practice in the climate science community,” and that “phrases such as ‘trick’ or ‘hiding the decline’ were colloquial terms used in private emails and the balance of the evidence is that [the scientists involved] were not part of a systematic attempt to mislead” (House of Commons, 2010). In all of this, what we observe in the actions of advocates and

skeptics is precisely what is to be expected under an ideological believer/skeptic dichotomy: both sides responding to the situation by more firmly entrenching themselves in their already established views.

Perhaps of greatest importance is that acceptance of the believer/skeptic dichotomy by some scientist activists has produced the *unintended* and perhaps *unintuitive* effect of leaving the science itself vulnerable to attacks by dissenters, powerful stakeholders, and political opposition. By buying into the illusion of having certain knowledge, scientist activists set the stage for inevitable disaster. They were counting on the science to prove something that the scientific method is incapable of proving: indisputable hard facts.

Framing the scientific argument for policy intervention in terms of indisputable scientific truths claims and complete consensus within the scientific community is flawed on multiple fronts. First, science is inherently probabilistic and any attempt to hide the uncertainty will always backfire when the uncertainty surfaces and the public realizes that what they were told was indisputable really is not. It is hard to believe the statement made by both the heads of the British Royal Society and US National Academy of Sciences that “neither recent controversies, nor recent cold weather, negate the consensus among scientists” (Rees, 2010), when just last month aforementioned MIT climate scientist Dr. Richard Lindzen gave expert testimony at a House Subcommittee on Science and Technology vehemently opposing the anthropogenic climate change hypothesis (Lindzen, 2010). Second, by not acknowledging the uncertainty outright, scientist advocates allow for a framework which gives dissenters a significant logical advantage. More will be said on this later. For a prominent example of the failure to acknowledge scientific uncertainty in climate science backfiring, we return again to the “climategate” scandal at the University of East Anglia. Although the leaked emails and documents did little to undermine the overall strength of the scientific argument supporting the anthropogenic climate change hypothesis, the scandal shattered much progress that had been made with regards to public opinion. As John Tierney of *The New York Times* put it, “these researchers, some of the most prominent climate experts in Britain and America, seemed so focused on winning the public-relations war that they exaggerated their certitude—and ultimately undermined their own cause” (Tierney, 2009).

For any true progress to be made towards a strong policy response, scientists who decide to take on an advocacy role must do a better job framing the debate in terms of the complexity and uncertainty, but to do so will require a realistic portrayal of the nature of scientific knowledge and just what it is that scientific inquiry does and does not convey. Much can be learned regarding the nature of climate science and how to properly frame the argument for policy intervention by considering leading theories regarding the ontology of scientific truth, and by looking at historical examples of knowledge assessment that are similar to current assessments of climate science. In the end, these considerations of the history and philosophy of science suggest a better portrayal of the evidence supporting the anthropogenic climate change hypothesis not in the sense of affirming or refuting the hypothesis, but rather in terms of risk assessment and to consideration of how best to go about mitigating risk in light of potential catastrophic impacts on both the economy and environment. Framing the scientific argument in terms of risk mitigation accurately acknowledges the uncertainty in the science and forces scientist advocates and policy makers to focus more on emphasizing the importance of risk management and risk mitigation instead of fighting endlessly over absolute knowledge affirmation.

II. Facts, Falsification, and Scientific Paradigms

The arguments presented in the remainder of this paper, in favor of greater public recognition of uncertainty by scientists and policy advocates, are made in the spirit of what Mary Tiles and Hans Oberdiek identify in *Living in a Technological Culture*. They state:

Philosophical reflection may be able to make a contribution to the discussion of issues which have drawn the thoughtful attention of reflective scientists, engineers, and policy makers...one may see how to *rethink* and thereby begin to *restructure* a practice so that what troubles, bothers, and perplexes and sometimes torments need not arise in so acute a form (Tiles, 1995).

Consideration of the history and philosophy of science is helpful because it allows us to take a step back from the complex details of the situation at hand and explore more broadly some of the meta-issues within which the details are confined. It allows us to think more broadly on how to properly frame the argument in such a way that we see the forest for the trees. In the context of climate change, historical and philosophic inquiries offer two unique perspectives. First, consideration of philosophy allows for thoughtful reflection on the epistemological justification of truth claims concerning climate change. In this case the truth claims are based on the scientific method which is inductive in nature and therefore postulating scientific truth claims as indisputable is epistemologically inconsistent; indisputable truth claims belong to the realm of deductive not inductive logic. Second, looking at historical perspectives provides the benefit of hindsight; something not afforded consideration of contemporary issues. By identifying and studying historically similar incidences we can better understand which factors play a significant role in addressing the issues at hand.

Indeed, much of what has troubled, bothered, perplexed, and perhaps tormented climate scientists and policymakers when dealing with climate change has arisen out of a misrepresentation, misunderstanding, or failure to fully acknowledge the nature of scientific knowledge and how scientific “truths” come to be accepted by the scientific community. In rethinking and restructuring a proper representation, we consider three elements of scientific inquiry: metaphysical truths and scientific “facts,” the logic of the scientific method and falsification, and the history of scientific paradigms.

A key misrepresentation regarding the science of climate change deals with facts. When we think of facts we often think of them as being what is beyond dispute; that the evidence supporting them is so overwhelming that it couldn’t possibly be otherwise. The problem however is that the scientific method by which theories of climate change are produced does not generate facts in this kind of metaphysical sense. The strength of scientific inquiry is not in the product being something that is beyond dispute, but rather that the method of formulating hypothesis and testing them is an objective one in which we place great value in the method itself. The method does not guarantee that the products will be irrefutable, but rather provides the context in which objective and unbiased critical reasoning can occur. As Tiles and Oberdiek observe, “if there is an association between science and facts it must be that scientific methods are regarded as being the most reliable we have available for determining the answers to questions we may have about the world.” (Tiles, 1995). The reason why we give so much clout to knowledge obtained by the

scientific method is not because it is indisputable, but rather because we have found the method to be the most effective in explaining a wide array of naturally observed phenomena and we expect claims obtained by the method to be superior to other methods of knowledge generation.

Although we often give the products of scientific inquiry the designation of being facts, this is only superficial in that it represents the trust made in methods of scientific investigation. Even then, this status is only granted *gradually* over time as scientists become more and more confident in their discoveries and observations. Despite this confidence, what is often acknowledged but overlooked in climate science is that there is a provisional quality to any knowledge obtained using scientific inquiry including what we may colloquially refer to as fact. Present theories are always subject to subsequent revision and are often heavily revised in the face of new and improved evidence. While climate change advocates point to the strength of the scientific method in producing climate models and projections of future impacts as the most reliable for establishing knowledge, they must not fail to also acknowledge that the truth claims generated are not factual in an ontological sense, and that by the nature of the scientific method, all truth claims are subject to reevaluation. In addition, while skeptics might point to the constant revisional process of scientific inquiry as evidence of faulty knowledge and subjectivity, they must remember that scientific inquiry is a time proven method that has been reliable again and again for explaining natural phenomena. The results that are produced by climate scientists are not simply a matter of personal opinion.

A second misunderstanding of the nature of climate science that relates to the logic of scientific inquiry is in recognizing that science does not produce positive knowledge. It is this misrepresentation that often leads to the products of scientific inquiry being viewed as facts in a metaphysical sense. If we look closely at the logic underlying the scientific method we see two distinct logical entities: observations which are *existential*, and theories which are *universal*. Observations have the characteristic of being true of a particular instance. We can observe a red rose in a garden, and insomuch as others observe the same thing, we can infer that there does *exist* a red rose in the garden for that particular instance. With observations you are only able to make truth claims that are existentially quantifiable.

With theories on the other hand, the goal is to make some kind of truth claim that holds universally. How can we say that *all* the flowers in the garden are red without observing every one? Universal truth claims are much more powerful than existential claims because they can be made not only in reference to past and present observations, but also provide the ability to make projections regarding future observations as well. The main purpose of the scientific method is to *provide a logical step in going from the existential to the universal*. This is done by presenting some sort of universal truth claim in the form of a hypothesis, and inasmuch as the observations used to test the hypothesis are consistent with the expected outcome, the universal truth claim posed by the hypothesis is accepted as a true theory. The problem with this is that going from the existential to universal is logically inductive. If you misinterpret it as being deductive you commit the logical fallacy of existential generalization. One cannot deductively generalize from a collection of individual observations to a universal statement that holds true for all possible instances. One cannot say that just because two, or twenty, or two hundred, or two thousand red roses are observed in the garden that all roses in the garden are red. Although the observation of more and more red roses adds additional support to the

universal statement that all roses in the garden are red, it never *positively* proves it. It is always that case that sometime in the future a white rose could be discovered.

This logical problem with the scientific method has led philosophers of science to view theories obtained through scientific inquiry not as truths that have been positively affirmed, but rather as truths that have yet to be refuted. The term as famously coined by Karl Popper is that all scientific knowledge is *falsifiable*. The longer a scientific theory goes without being refuted the stronger the theory becomes, but the absence of refutation never constitutes positive affirmation. It is always possible that some future observation could overturn what is collectively accepted as indisputable by the scientific community today. Recognition of the logic of scientific inquiry and falsifiability demonstrates why framing climate science as indisputable gives dissenters an upper hand. If you properly frame the science of climate change in terms of inductive reasoning and uncertainty your argument may not carry the strength of something that is absolute, but it can still remain strong and compelling. When framed inductively, a single piece of evidence contrary to the anthropogenic climate change hypothesis *does not* seriously threaten the overall position; you can still point to all the other evidence in your favor. If I say, after observing 20,000 red roses there is strong reason to believe most all roses in the garden are red, the presence of a single white rose presented by someone dissenting from my position doesn't repudiate the fact that there still are 20,000 red roses.

On the other hand by ascribing to the theory of climate change the property of indisputability, as if it had been derived deductively, a single piece of evidence contrary to the theory *does* undermine the entire position. This is based on what is called argument by refutation, or what philosophers and logicians refer to as *reductio ad absurdum*. If scientist advocates claim emphatically there is complete consensus among the scientific community and that the science is settled, even one dissenter or one study that is later overturned reveals to the public non-consensus and inconsistency; the presence of one dissenting scientist, such as Dr. Lindzen giving testimony before the House Subcommittee, is enough to bring the entire tower of cards crashing down. Just one white rose in a garden of red roses is enough to overturn the assertion that *all* roses in the garden are red.

The final, and perhaps most crucial concept that is often overlooked concerning climate change science is the idea that science has historically progressed through a series of scientific paradigms where a certain worldview and set of scientific theories dominate for a given period of time, but are later replaced as old theories are refuted and new theories are made in their place. This happens with theories being deconstructed in the face of phenomena they can't explain, after which new theories are reconstructed so as to explain both past observations and the phenomena which led to the deconstruction of the old theories to begin with. This view of science is most famously advocated in *The Structure of Scientific Revolutions* by Thomas Kuhn. By acknowledging the nature of changing scientific paradigms, members of the climate science community should realize that scientific consensus is a rare thing and that science has evolved prominently as a result of, not despite, competing scientific theories.

While paradigm shifts are often small in their scope and confined within disciplines, they can also be expansive and transcend what has long been accepted without opposition. By looking at the history of science we see that cycles of evolving scientific paradigms is the rule, not the exception. Beginning with the early Greeks many theories were postulated regarding the fundamental nature of matter; Thales said everything was made of water,

Anaximenes said everything was air, Heraclitus said all was fire, while finally around 350 B.C. Aristotle claimed that everything consisted of air, fire, water, and earth (Baird, Ancient Philosophy, 2003). Over the course of the proceeding centuries, Aristotle's theory on the nature of matter along with his other scientific theories on causation, logic, and astronomy were more widely accepted. By the 1st century, most of Western and Islamic science had incorporated the entirety of the Aristotelian scientific paradigm with some additional influence from other notable thinkers such as Ptolomy and Galen (Gutas, 1998). Gradually as centuries passed, challenges to the Aristotelian paradigm arose and more and more phenomena were observed that the Aristotelian paradigm was incapable of explaining. Where Aristotle claimed that the earth was the center of the universe, Copernicus argued circa 1500 A.D. it was the sun. Where Aristotle claimed that everything in the heavens was made of a perfect celestial matter, Galileo—with the use of the then newly invented telescope circa 1600 A.D.—observed mountains and craters and other imperfections on the moon (DeWitt, 2004). Where Aristotle claimed that the universe was finite, many astronomers began to suspect while gazing into the heavens that the universe may actually be infinite. What we see in all of these examples is a growing deconstruction of the Aristotelian paradigm as more and more phenomena were observed that the paradigm was incapable of explaining.

Although there were various individuals that contributed to the reconstruction of a new scientific paradigm after the deconstruction of the Aristotelian worldview, we give most of the credit to Sir Isaac Newton. What we find in Newton's *Principia* and the three laws of motion is exactly what is to be expected under Kuhn's view: a new set of laws and theories that collectively explain past observations, but that also explain the phenomena that led to the deconstruction of the Aristotelian paradigm in the first place. In comparison to Aristotle, however, the success of the Newtonian paradigm was short lived as Newtonian theories are found in the late 1800s to predict behavior contrary to what was experimentally observed. In particular, the ultraviolet spectrum of blackbody radiation, the monoenergetic nature of light coming from heated elements, and the properties of radioactivity were all unexplainable under the Newtonian paradigm (DeWitt, 2004).

As Kuhn would expect, we see a subsequent deconstruction of the Newtonian worldview and a reconstruction of a scientific paradigm with the addition of Einstein's special relativity and quantum theory as advanced by Schrödinger, Bohr, Planck, Heisenberg and others. But even among these physicists there was still a lack of consensus. The most notable example comes from Einstein's objection to uncertainty in quantum mechanics when he emphatically claimed, largely on the basis of *ideological* religious views, that "God does not play dice with the universe" (Born, 1971). As much as we revere Einstein for his unprecedented insights regarding special relativity, even he couldn't fully separate ideology from scientific inquiry and could not have been more wrong when it came to quantum mechanics. While today we largely live and operate in the paradigm of special relativity and quantum theory, new developments in sub atomic particle physics are once again challenging conventional scientific understanding and if history has a way of repeating itself, it is only a matter of time before our own current paradigm is the victim of yet additional unexplainable phenomena and is laid to rest in the ever growing graveyard of failed scientific theories.

From Kuhn's historical portrayal of science as a history of scientific paradigms, we gain two important insights into the science of climate change. First, we learn that "if both

observation and conceptualization, fact and assimilation to theory, are inseparably linked in discovery, then *discovery is a process and must take time*" (Kuhn, 1996). By this Kuhn is linking what was discussed previously regarding falsification and the logic of the scientific method with history. If in doing science we are logically going from the existential (or what Kuhn calls observations or facts) to the universal (what Kuhn calls conceptualization or theory), then discovery which is dependent on empirical observations can happen no faster than the rate at which empirical observations are made in support of universal theories. The lesson to be learned is that even short term scientific consensus takes time to develop and we cannot expect science to deliver concrete results overnight. Despite all that current science on climate change tells us, there still remain significant uncertainties which will only be resolved over the course of time. This presents a significant challenge to policymakers because if consensus and reduction of uncertainty takes time, and if action is required now to mitigate catastrophic effects of climate change later, then policymakers will have to make key decisions concerning policy response with uncertain, incomplete, and imperfect information.

The second lesson we learn is that "history suggests that the road to a firm research consensus is extraordinarily arduous" (Kuhn, 1996). This is largely because even in the face of strong and compelling evidence, dissenters play a *necessary* role in providing critical assessment of popular theories. When dissent is acknowledged, it forces proponents of the anthropogenic climate change hypothesis to develop even stronger scientific evidence and to look for additional ways of reducing the scientific uncertainty. In this context *acknowledging and responding* to the dissenters by generating stronger evidence and reducing uncertainty actually ends up *strengthening* the scientific argument for policy intervention instead of weakening it. This runs contrary to how many scientist advocates are trying to deal with dissenters. As Kuhn's history of scientific paradigms has shown, non-consensus at the beginning leads to stronger and more powerful theories in the end, not weaker ones.

III. Uncertainty and Stakeholders: Lessons from the Copernican Revolution

A good way to illustrate the philosophical contribution that facts, falsification, and scientific paradigms play in properly framing the assessment of climate science and arguments for policy intervention is by contrasting knowledge assessment of climate change with the historical example of the Copernican Revolution. In this example we see all the elements we have discussed thus far at work as we shift from a geocentric to heliocentric model of the universe and from circular to elliptical orbits. We look at knowledge assessment in the Copernican Revolution because it is similar to knowledge assessment of climate change in multiple ways; in both we see uncertainty in the science in how to theoretically model a natural system, and we see uncertainty in the observations and data supporting the theories. We also see the presence of large influential and powerfully entrenched interests with much riding on the scientific outcome.

Although the Copernican Revolution officially commenced in 1543 with the publication of *On the Revolutions of the Heavenly Spheres* by Nicholas Copernicus, the true beginning stems from Aristotle's concept of the universe as portrayed in *On the Heavens*. According to Aristotelian astronomy the earth is a stationary sphere sitting at the center of the universe. All other heavenly bodies such as the sun, moon, stars, and planets are made

of perfect matter and reside in multiple levels of concentric spheres surrounding the earth in the same way that an onion consists of multiple layers. Aristotle viewed the heavens as a place of perfection and this view influenced his characterization of the motion of heavenly bodies in two ways. First, he viewed the circle as being the perfect geometric shape and concluded that all heavenly bodies must follow perfect circular orbits. Second, he thought that for something to be perfect it must also be unchangeable and concluded that if the heavens were a place of perfection, then all heavenly motion must be uniform and constant.

The first major addition to Aristotelian astronomy was made around 150 A.D. by Ptolemy, a Roman mathematician and astronomer living in Alexandria. In his treatise the *Almagest*, Ptolemy takes all the fundamental tenets of Aristotelian astronomy—a geocentric universe with perfect circular uniform motion of the heavenly bodies—and uses them as premises to derive a complex mathematical model of the universe. In doing this, Ptolemy finds it difficult to account for the motion of Mars and Venus and introduces a number of complex geometrical modifications to the system including epicycles, deferents, eccentrics, and equant points (knowledge of the details of these geometric tools is not necessary for the current discussion). Although these modifications did not resolve all the discrepancies with observation, they greatly improved the model and were generally seen as being on the right track. These modifications left Aristotle’s fundamental premises intact, but did so at the expense of increased complexity. The most difficult observation for the model to explain was the retrograde motion of the planets as they appeared at times to be moving forward in their orbits and then stop, backtrack a short distance, and then resume moving in the original direction. The model presented by Ptolemy in the *Almagest* was widely accepted and remained virtually unchanged for roughly 1400 years until Copernicus’ introduction of the heliocentric model (DeWitt, 2004).

Although Copernicus is often viewed as a revolutionizing western thinker by shifting us from a geocentric to heliocentric worldview, his motives were primarily to simplify some of the complexity of the Ptolemaic model. Other than the geocentric/heliocentric change, there is otherwise little difference between the models of Ptolemy and Copernicus. As a technical matter, the only real advantage of the Copernican model was its ability to explain the retrograde motion of the planets without the use of epicycles. What is most interesting in the context of entrenched stakeholders influencing scientific outcomes is that although Copernicus had established much of his model of a heliocentric universe early in his life, he was hesitant to disseminate it out of fear of retribution from the Roman Catholic Church and it wasn’t until his death in 1543 that *On the Revolutions of the Celestial Spheres* was first published. In an effort to curtail the Church’s response and avoid possible punishment, he even went so far as to dedicate the entire work to Pope Paul III.

The reason for the Church’s rejection of the heliocentric model stems largely from the fusing of Aristotelian science with Christian theology by St. Thomas Aquinas. Aquinas was a Dominican monk that lived from 1225-1274 A.D., and his primary interest was in overcoming disputations between philosophy and religion. Aquinas thought that there were no natural conflicts between philosophy and Christian theology and set out to prove that reason was capable of deriving religious truth. To do this, Aquinas accepted Aristotelian categorical logic and science and in *Summa Theologica* used both to derive a rational justification for every point of Christian doctrine (Baird, 2003). Although *Summa Theologica* and other teachings were initially condemned by the Church, the condemnation

was short lived and Aquinas was canonized in 1323 A.D.. Over the subsequent years, much of Aquinas' theology came to be accepted as the official stance of the Catholic Church on many points of doctrine. This however created an intricate problem. Because Aquinas had premised much of his rational justification for tenets of Christian doctrine on Aristotelian science and philosophy, and because the Catholic Church had accepted Aquinas' theology as its official stance on many points of doctrine, any refutation of Aristotelian science was viewed as a direct challenge to the official doctrine of the Church. We see in works such as Dante's *Divine Comedy*, the Aristotelian model of the cosmos permeating Christian doctrine so that by the time Copernicus came along the Church was highly entrenched in a geocentric worldview and had insurmountable incentive to maintain what was consistent with official Church dogma.

What we see in this piece of the historical example is similar—although not entirely analogous—to the contemporary situation with climate change. Much in the same way that the Catholic Church was dependent on perpetuating the geocentric worldview to maintain official dogma and thus tried to delegitimize Copernicus' heliocentric theory; petroleum and coal companies heavily invested in hydrocarbon fuels that emit carbon dioxide are dependent on a world where carbon emissions are admissible and therefore have strong incentive to delegitimize scientific evidence supporting the anthropogenic climate change hypothesis. One example of exactly this kind of behavior is Exxon Mobil which has spent hundreds of thousands of dollars funding lobbying groups to publish blatantly misleading and inaccurate information concerning climate science (Adam, 2009). Scientist advocating for a policy response to climate change may think that *knowledge affirmation* is the preferred way of framing the debate because of the strength of the scientific evidence, but the Copernican Revolution shows that pursuing an argument based on knowledge affirmation alone when confronted by entrenched interests is an arduous one and can take significant time. In the Copernican case it wasn't until 1822—almost 300 years after the initial printing of *On the Revolutions of the Heavenly Spheres*—that Pope Pius VII allowed books adhering to the heliocentric view to be printed in Rome. As mentioned previously, this is problematic because if catastrophic climate change is dependent on aggressive policy intervention now, we cannot wait for issues of knowledge affirmation to sort themselves out. *Advocates for policy intervention therefore must look to some other means of framing the science to bring about a call to action.*

In continuing the historical dialogue, sometime after Copernicus a third model was developed by Tycho Brahe around 1600 A.D. that tried to blend the Ptolemaic and Copernican models while retaining the perfect circle and constant motion facts of Aristotelian astronomy. In his model, Brahe stuck with the Ptolemaic view by having the earth at the center of the universe with the sun and moon revolving around the earth, but then adopted the Copernican view by having the planets orbiting the sun. What is telling is that despite the significant differences among the underlying theories of Ptolemy, Copernicus, and Brahe, all three models were mathematically identical and predicted the exact same phenomena. As Kuhn observes, “philosophers of science have repeatedly demonstrated that more than one theoretical construction can always be placed upon a given collection of data” (Kuhn, 1996). In the end, all three models essentially described the same motion using different underlying premises, but none were able to completely overcome some of the discrepancies observed in the motion of the planets.

Shortly after Tycho Brahe we see yet a fourth model proposed by German mathematician and astronomer Johannes Kepler and it is with Kepler, not Copernicus, that the fundamental breakthrough occurs. In constructing his model, Kepler was aided by two things. First, Kepler concluded on the onset that no model based on the two Aristotelian “facts” of perfect circular motion and constant uniform motion were capable of fully explaining the orbit of Mars. Second, as an assistant to Brahe, Kepler had access to arguably the best astronomical data of the time. After dismissing what had been generally accepted as indisputable truth and “facts,” Kepler went about experimenting mathematically with a variety of different shapes and speeds of orbits, seeing what best matched the data, until he finally settled on a heliocentric universe with the planets revolving in elliptical orbits at varying speeds. By rejecting the “facts” Kepler was able to accomplish what Ptolemy, Copernicus, and Brahe hadn’t which was a theoretical description of heavenly motion that was completely consistent with observations and did so without the use of epicycles, deferents, eccentrics, or equant points.

At this point we see the arguments addressing facts, falsifiability and scientific paradigms coming full circle. In both the climate change and Copernican Revolution cases we see scientists trying to explain natural phenomena by constructing scientific models. In the case of the Copernican revolution the main challenge to constructing the models was overcoming the lock-in that had occurred when the Aristotelian “facts” of perfect circular motion and constant uniform motion were viewed metaphysically as absolute truths. It was only when there was an environment of non-consensus where these “facts” were challenged that the science was finally able to progress. Had early astronomers understood falsification and the logic behind scientific “truth” they may have started much earlier to challenge Aristotelian science and look for alternative orbit shapes as Kepler did eventually. Had they done so, they may have arrived at a consistent theory much sooner. This is further evidence that science evolves as a result of, not despite, competing scientific theories, and scientist activists should welcome dissenting views as an opportunity to strengthen, not weaken, their position by acknowledging and responding to dissenters through the generation of stronger scientific evidence. This will continue to be important as climate scientists continue the challenging but crucial task of improving climate models through greater understanding of current areas of uncertainty such as water vapor feedback.

If anything, reflection on the Copernican Revolution shows us that the process of doing science itself is complex with varying degrees of uncertainty and the results are not something which can be thought of ideologically in a believer/skeptic dichotomy. Knowledge gained by scientific inquiry does not constitute facts in a metaphysical sense and is logically bound by the principle of falsifiability. We also see in the example of the Copernican Revolution that models of nature with different underlying assumptions are capable of explaining the same phenomena and our perception of which models we think are best is largely a function of where we sit in the historical scheme of things. In our case looking back we can see only in hindsight what the critical issues were in developing a proper model of the cosmos and it is only in hindsight that we can see where the real progress was made. With the current assessment of climate science we are not afforded the luxury of hindsight. Whether in a developmental state our current climate models are analogous to Aristotle’s, Ptolemy’s, Copernicus’, or Kepler’s models of the cosmos, only future climate scientists will be able to say.

IV. Knowledge Affirmation vs. Risk Mitigation

As evident by the recent decline in public opinion regarding the anthropogenic climate change hypothesis, it is apparent that framing of science in terms of indisputable truth claims and knowledge affirmation is not succeeding in calling for policy intervention. From the arguments that have been presented we have seen multiple explanations for why this is so: claiming consensus among scientists appears dubious when dissenting scientists are publically recognized; claiming climate science is indisputable is logically invalid as all scientific truth claims are falsifiable, there are no facts; truth claims based on the scientific method are inductive in nature and therefore postulating truth claims as indisputable is epistemologically inconsistent and vulnerable to backfire—e.g. “climategate”; pursuing an argument based on knowledge affirmation when confronted by powerfully entrenched interests is an arduous one and can take significant time to overcome, something that is unacceptable if policy action to mitigate future potential catastrophic events is needed now; scientific consensus is a rare thing and science has evolved largely as a result of, not despite, competing scientific theories, scientist advocates strengthen, not weaken their argument when they acknowledge and respond to dissenters; and finally, despite the strength of current science in support of the anthropogenic climate change hypothesis, there still remain significant uncertainties that must be overcome. Overall, the entirety of the arguments presented illustrates the futility of trying to frame the argument for policy intervention on the basis of indisputable scientific facts and certain catastrophic outcomes.

It is because climate change deals with science of such complexity and uncertainty that advocates calling for policy intervention cannot simply buy into the believer/skeptic dichotomy and expect to make any head way; advocates for policy intervention must look to other means of framing the science to legitimize a call for action. The uncertainty and complexity of the science deserves our attention because if there is any possibility of catastrophic consequences due to climate change, then responding to those future calamities must be begin today. One way that finality could be brought to the issue is by reframing the debate not in terms of strict scientific affirmation and indisputable evidence, but by embracing the uncertainty inherent in the science when addressing the general public and media and using that to promote policy action in terms of risk mitigation.

An accurate account of a risk mitigation framing of climate science is given by Dr. Mort Webster of MIT. In his paper *Uncertainty Analysis of Climate Change and Policy Response*, Webster states “while continued basic research on the climate system to reduce uncertainties is essential, policy-makers also need a way to assess the possible consequences of different decisions, including taking no action, *within the context of known uncertainties*” (Webster et. al., 2003). Webster goes on to say that:

Decision-making under uncertainty is an appropriate framework for the climate problem because of two basic premises: (i) the cumulative nature of atmospheric greenhouse gases, and the inertia of the oceans, means that if one waits to resolve the amount of climate change in 2050 or 2100 by perfectly observing it, it will take decades or centuries to alter observable trends—effective mitigation action must be started decades before the climate changes of concern are actually observed; (ii) a significant part of our uncertainty about future climate change may be unavoidable—details of

climate and weather over longer periods of time are likely to remain unpredictable to some degree...thus, informed climate policy decisions require current estimates of the uncertainty in consequences for a range of possible actions (Webster et. al., 2003).

Framing the scientific argument in terms of risk mitigation begins to resolve the problem in two ways. First, it presents the potential risks of global warming in such a way that properly acknowledges the uncertainty in the climate science and the epistemological nature of knowledge obtained through scientific inquiry. Second, it provides a reason to act now despite the lack of finality in assessment of the science. Dissenters may still not adhere to the anthropogenic climate change hypothesis, but if they were thinking about the problem in terms of uncertainty and risk mitigation instead of a false dichotomy of absolute certainty and knowledge affirmation, those who are risk adverse may be willing to agree on policy intervention without having to adhere to the global warming hypothesis. Implementing climate policy under a risk mitigation framework then becomes like an insurance policy where many don't envision ever having to use it, but buy into it anyway because it isn't worth taking the chance. Although reframing the climate debate in terms of risk mitigation will not resolve all the problems currently preventing a policy response, it is nonetheless a first and necessary step that lays the groundwork for a rational and pragmatic approach to dealing with climate change.

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